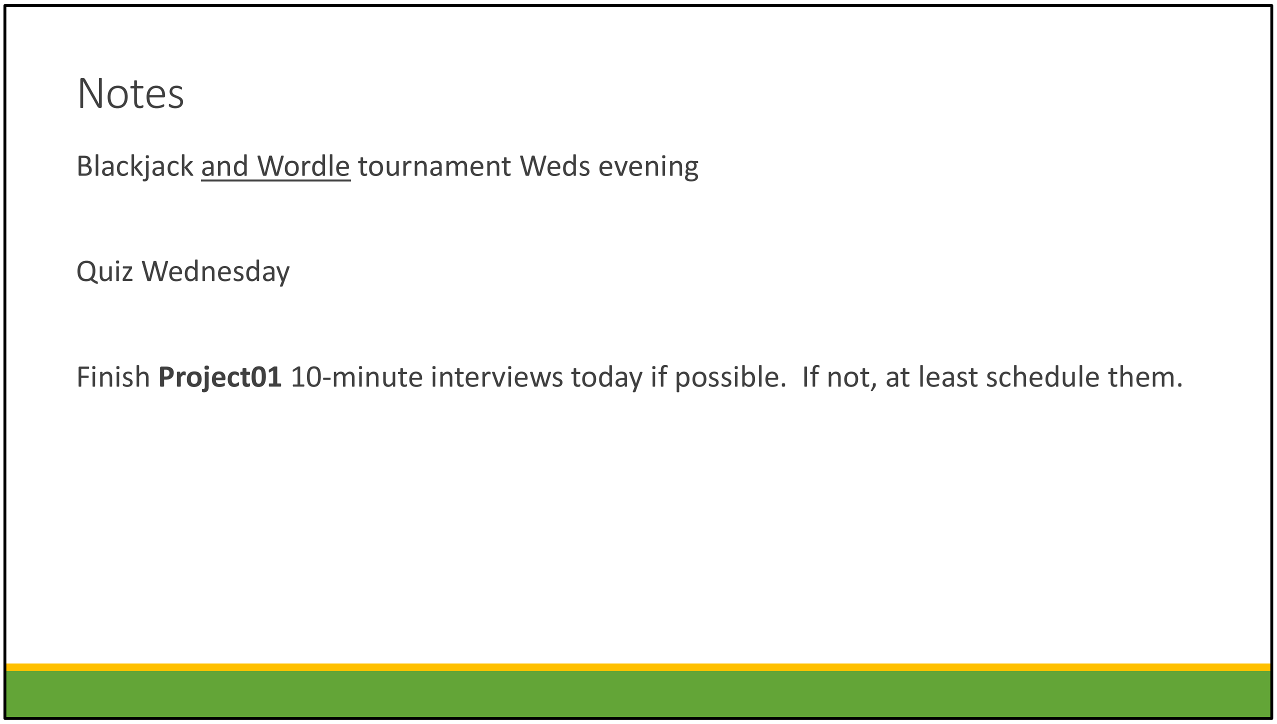


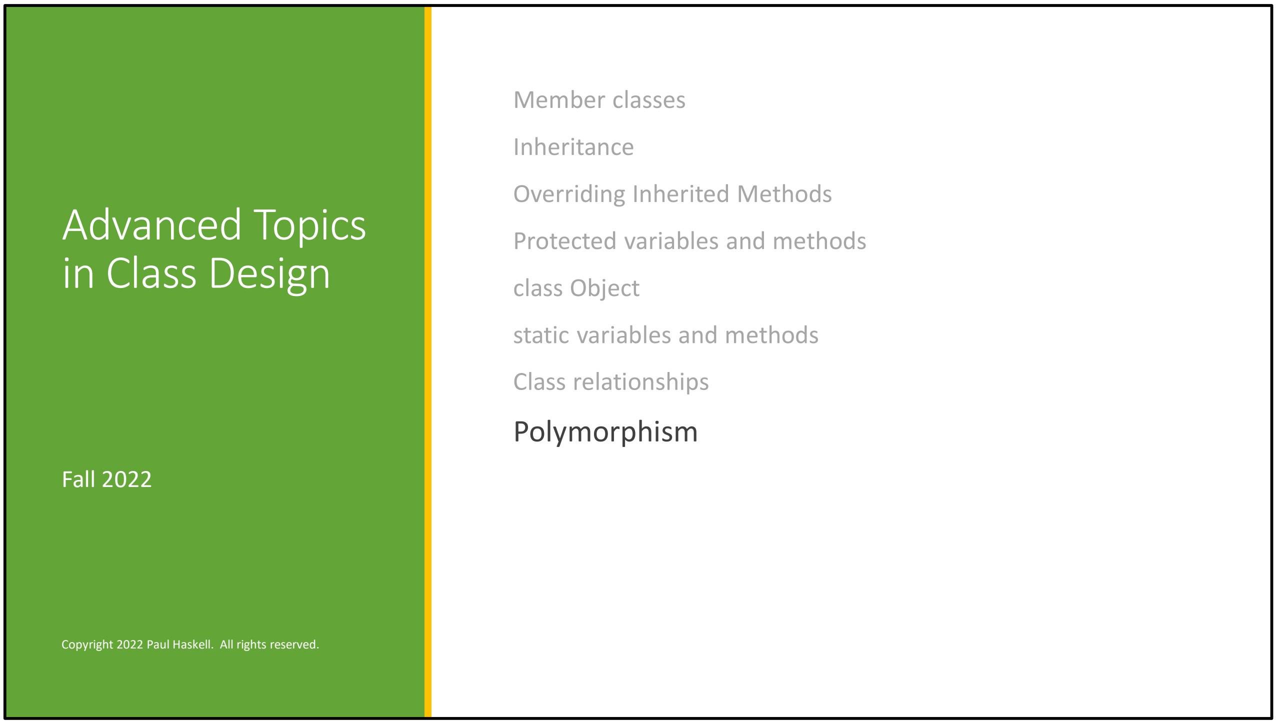
Notes

Blackjack and Wordle tournament Weds evening

Quiz Wednesday

Finish **Project01** 10-minute interviews today if possible. If not, at least schedule them.

Tournaments Weds 6:30pm, Lo Schiavo G12



Advanced Topics in Class Design

Fall 2022

Member classes

Inheritance

Overriding Inherited Methods

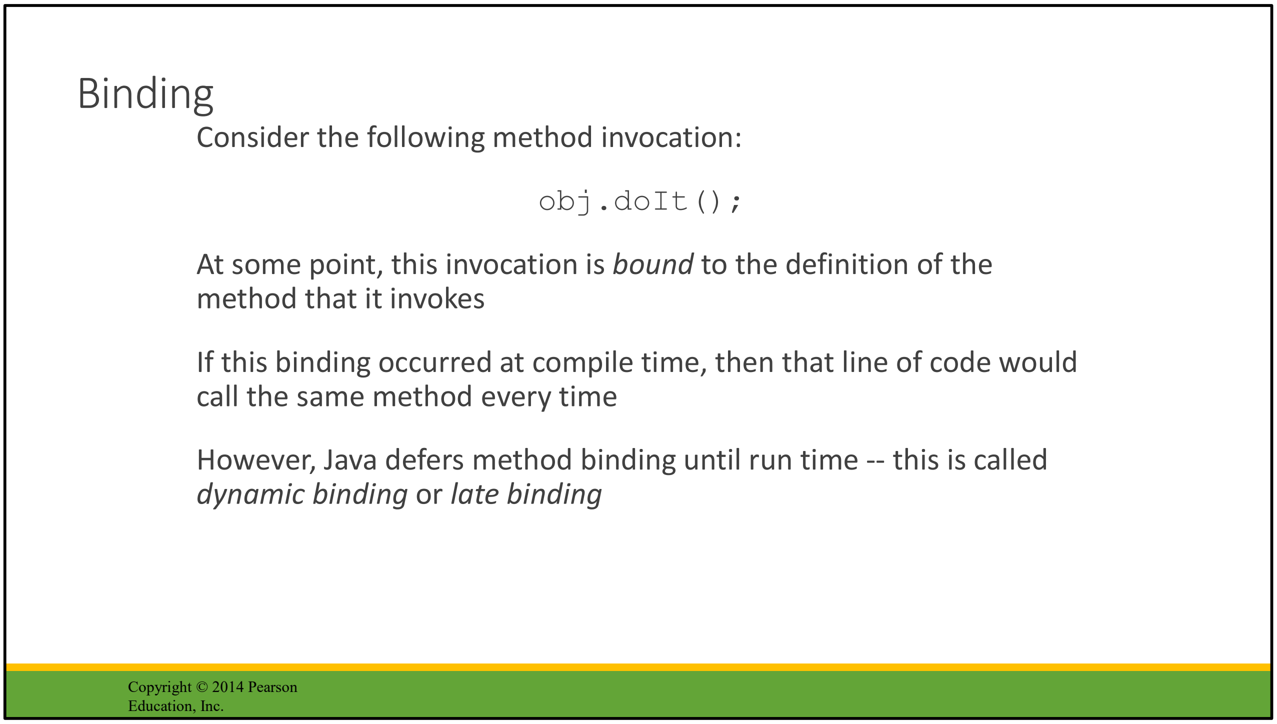
Protected variables and methods

class Object

static variables and methods

Class relationships

Polymorphism



Binding

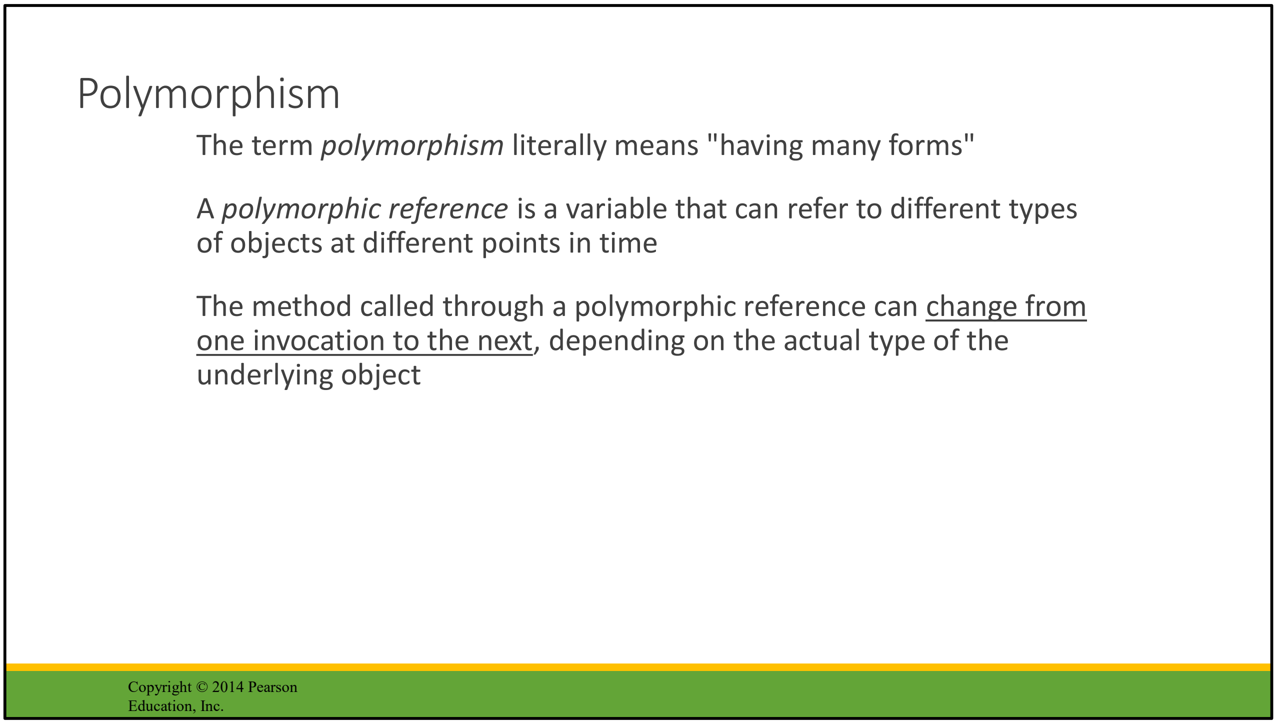
Consider the following method invocation:

```
obj.doIt();
```

At some point, this invocation is *bound* to the definition of the method that it invokes

If this binding occurred at compile time, then that line of code would call the same method every time

However, Java defers method binding until run time -- this is called *dynamic binding* or *late binding*

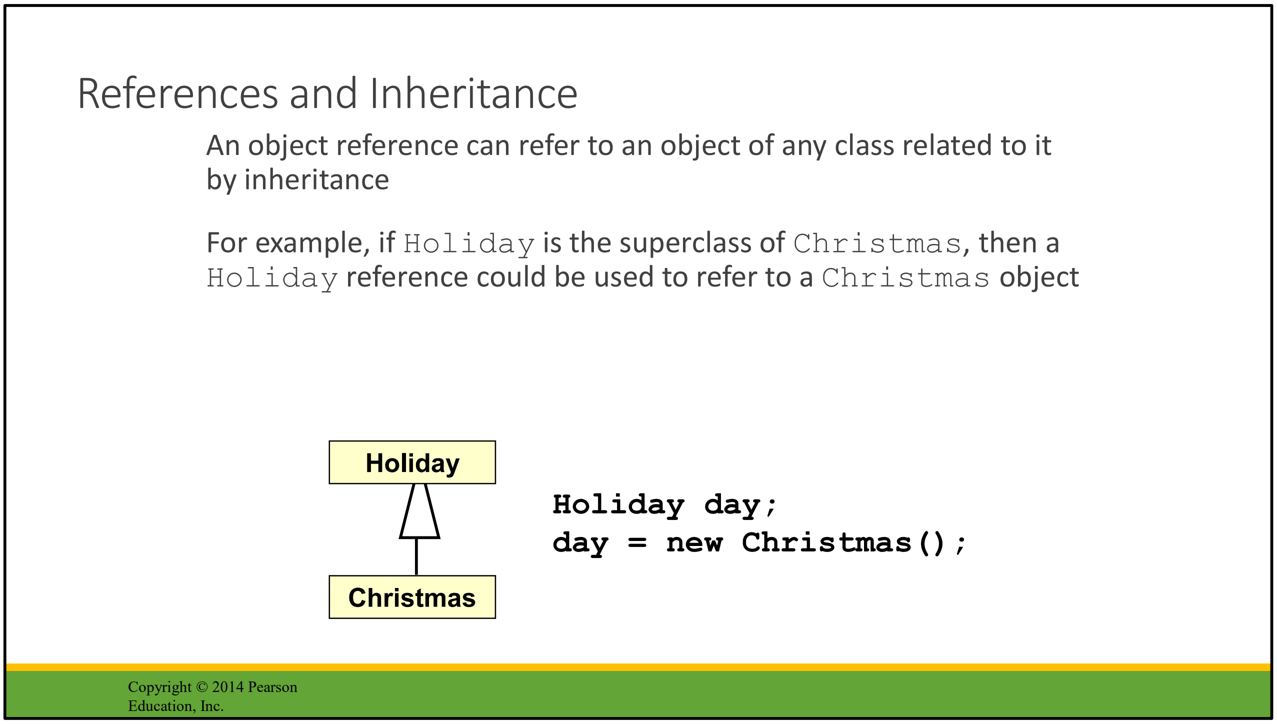


Polymorphism

The term *polymorphism* literally means "having many forms"

A *polymorphic reference* is a variable that can refer to different types of objects at different points in time

The method called through a polymorphic reference can change from one invocation to the next, depending on the actual type of the underlying object



References and Inheritance

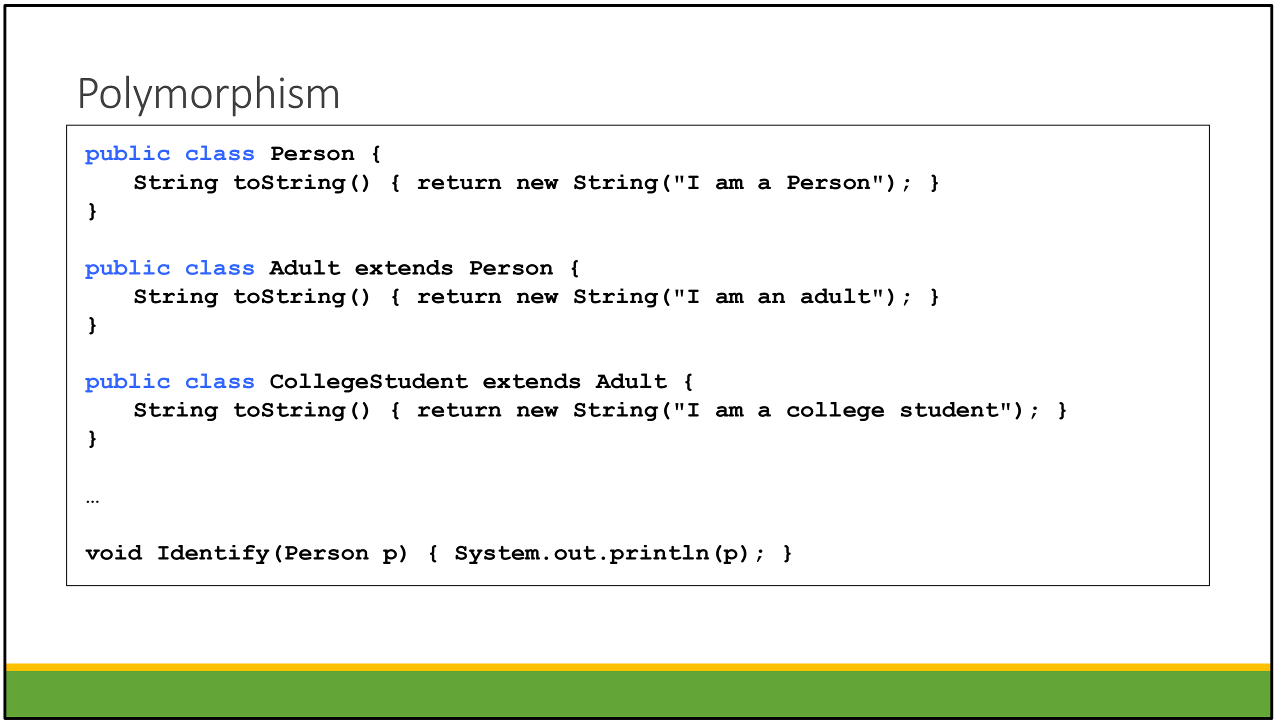
An object reference can refer to an object of any class related to it by inheritance

For example, if `Holiday` is the superclass of `Christmas`, then a `Holiday` reference could be used to refer to a `Christmas` object

Holiday

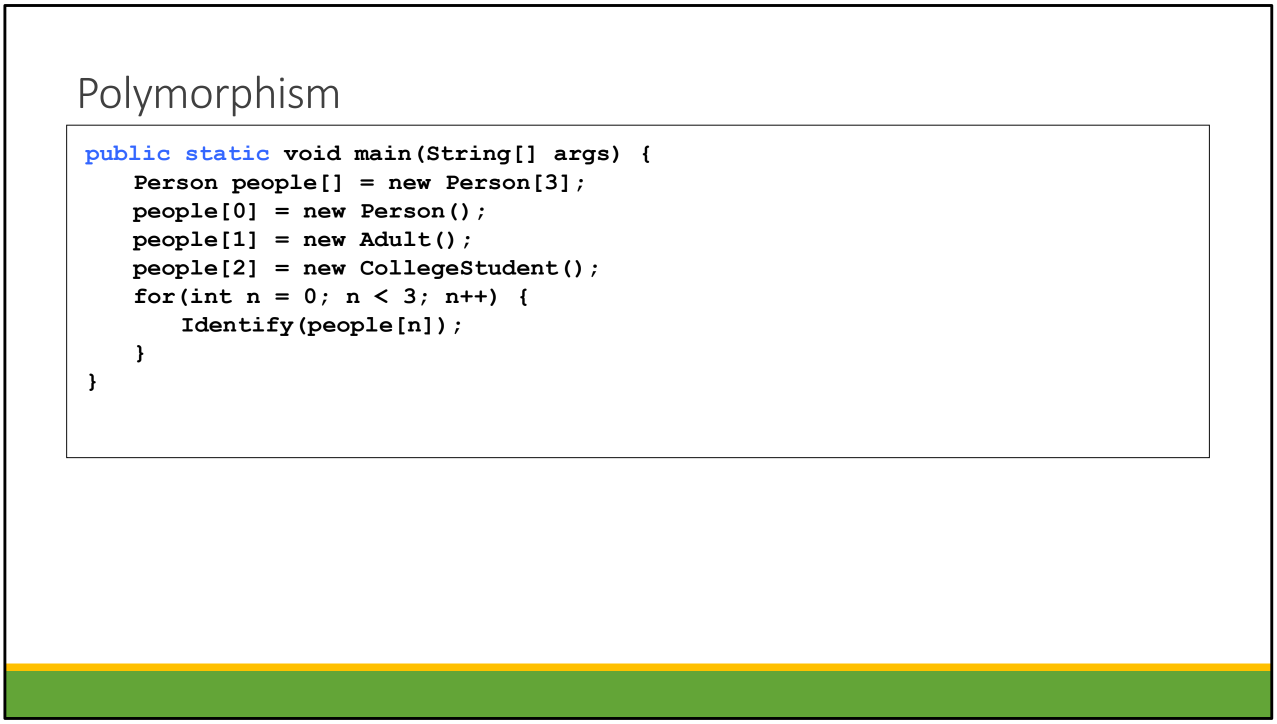
Christmas

```
Holiday day;
day = new Christmas();
```



Polymorphism

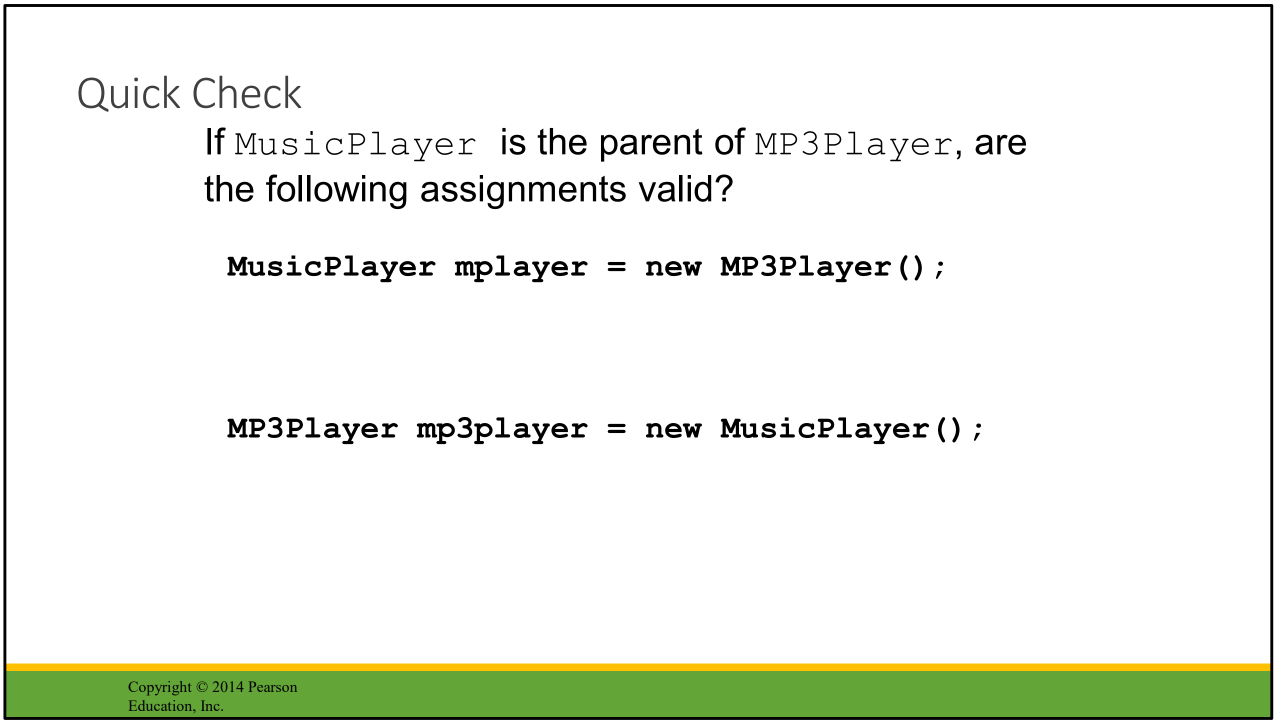
```
public class Person {
   String toString() { return new String("I am a Person"); }
}

public class Adult extends Person {
   String toString() { return new String("I am an adult"); }
}

public class CollegeStudent extends Adult {
   String toString() { return new String("I am a college student"); }
}

…

void Identify(Person p) { System.out.println(p); }
```



Polymorphism

```
public static void main(String[] args) {
    Person people[] = new Person[3];
    people[0] = new Person();
    people[1] = new Adult();
    people[2] = new CollegeStudent();
    for(int n = 0; n < 3; n++) {
        Identify(people[n]);
    }
}
```

LET'S UNPACK THIS. This prints the obvious. But HOW is important.
The Identify() function does not know about anything but Person. It just calls the toString() method on each object
Each object knows for itself which version of toString it should use
VERY POWERFUL
Users of a base class do not have to know details about derived classes! As long as derived classes do the right thing!
INHERITANCE V USEFUL IN SOME CIRCUMSTANCES. DON'T USE IT IF IT ISN'T NEEDED!



Quick Check

If `MusicPlayer` is the parent of `MP3Player`, are the following assignments valid?

```
MusicPlayer mplayer = new MP3Player();



MP3Player mp3player = new MusicPlayer();
```

Advanced Topics in Class Design

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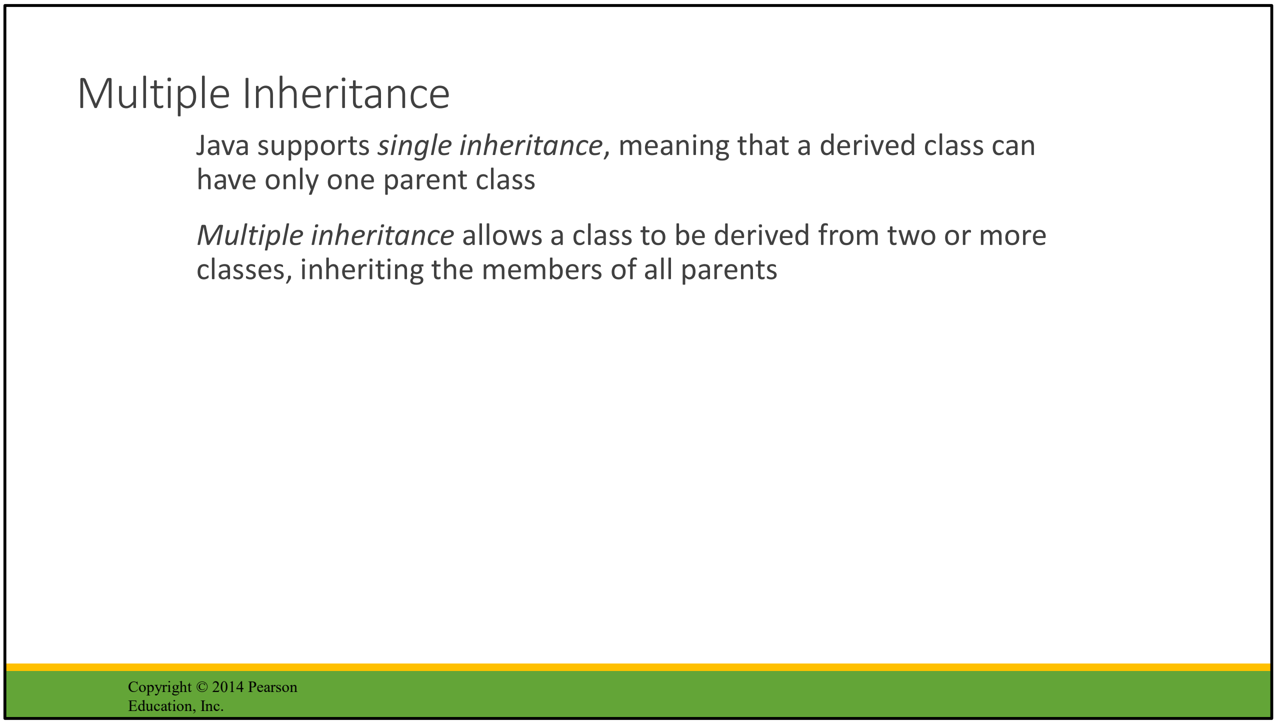
static variables and methods

Class relationships

Polymorphism

Multiple inheritance, Interfaces, and Abstract classes

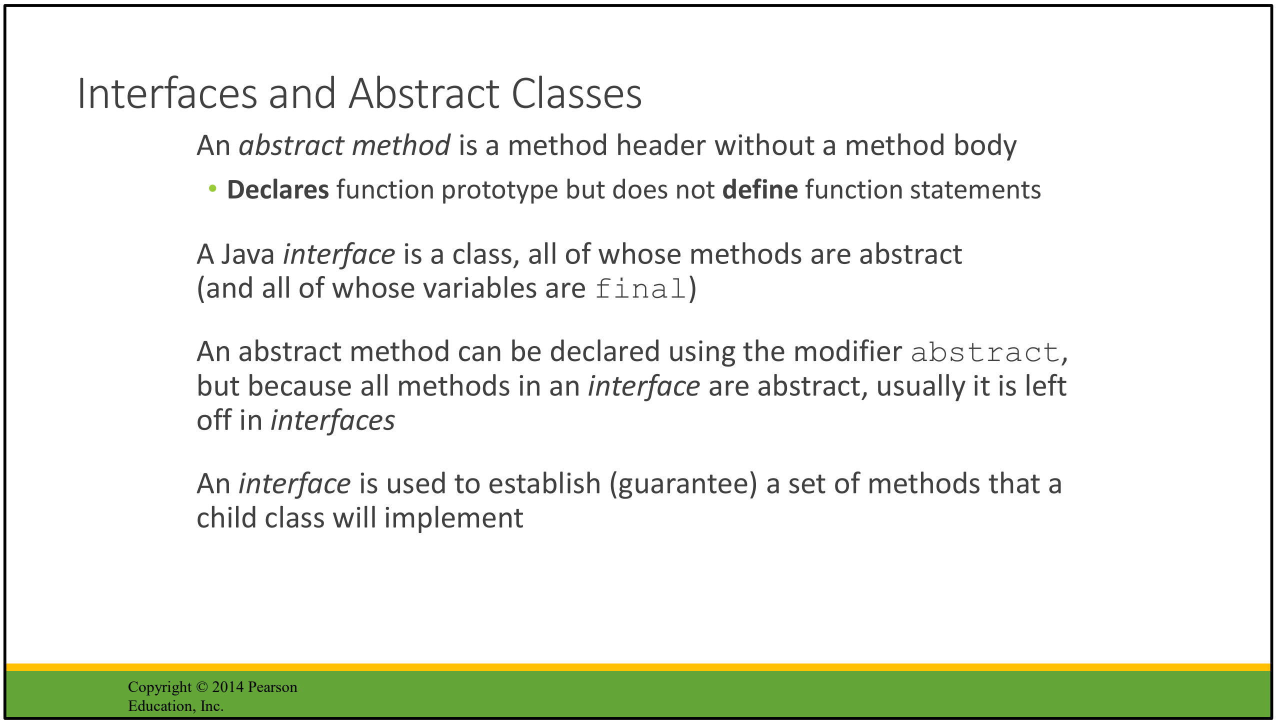


Multiple Inheritance

Java supports *single inheritance*, meaning that a derived class can have only one parent class

Multiple inheritance allows a class to be derived from two or more classes, inheriting the members of all parents

INTERESTING JAVA DESIGN PHILOSOPHY. WALK THRU NAMESPACE COLLISION PROBLEM



Interfaces and Abstract Classes

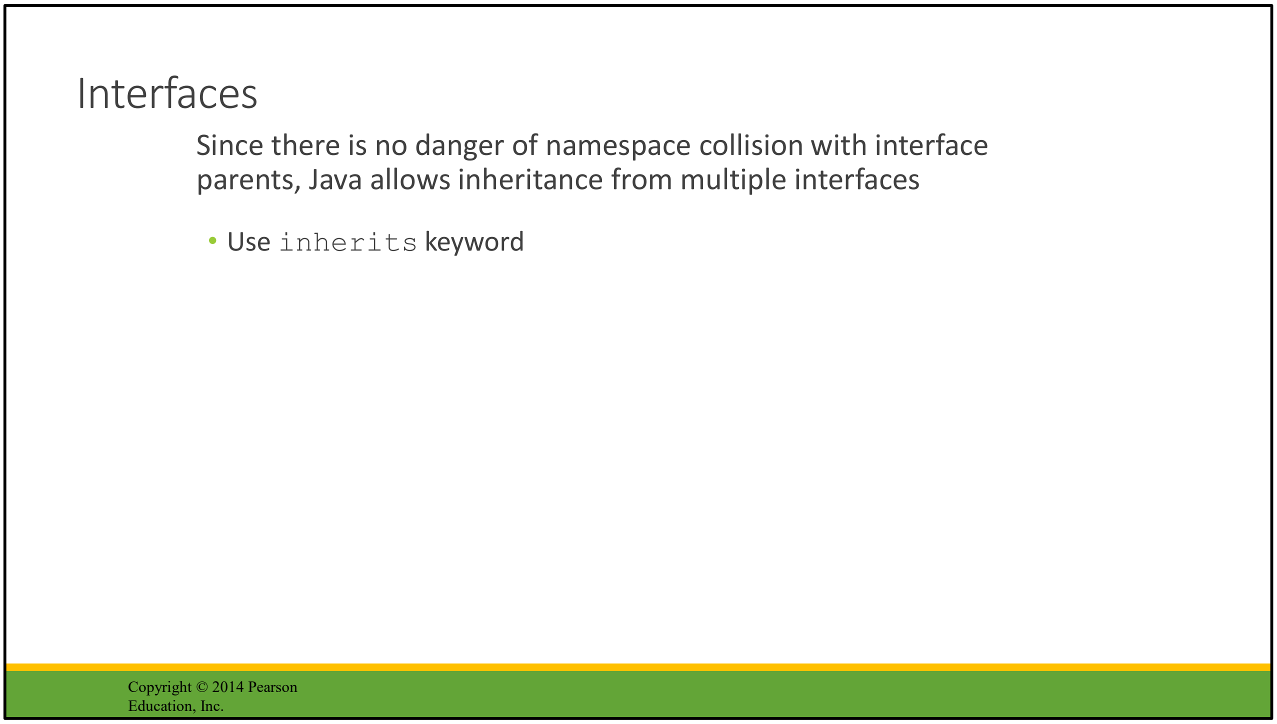
An *abstract method* is a method header without a method body

- **Declares** function prototype but does not **define** function statements

A Java *interface* is a class, all of whose methods are abstract
(and all of whose variables are `final`)

An abstract method can be declared using the modifier `abstract`, but because all methods in an *interface* are abstract, usually it is left off in *interfaces*

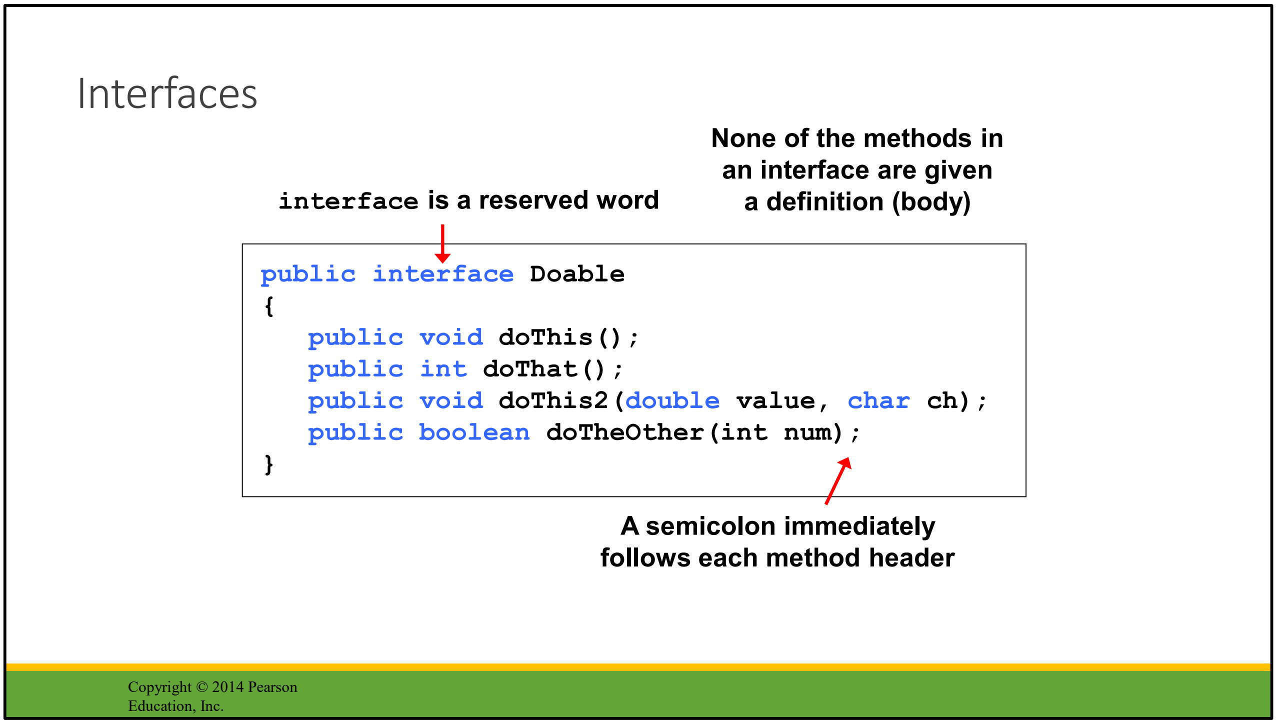
An *interface* is used to establish (guarantee) a set of methods that a child class will implement



Interfaces

Since there is no danger of namespace collision with interface parents, Java allows inheritance from multiple interfaces

- Use `inherits` keyword



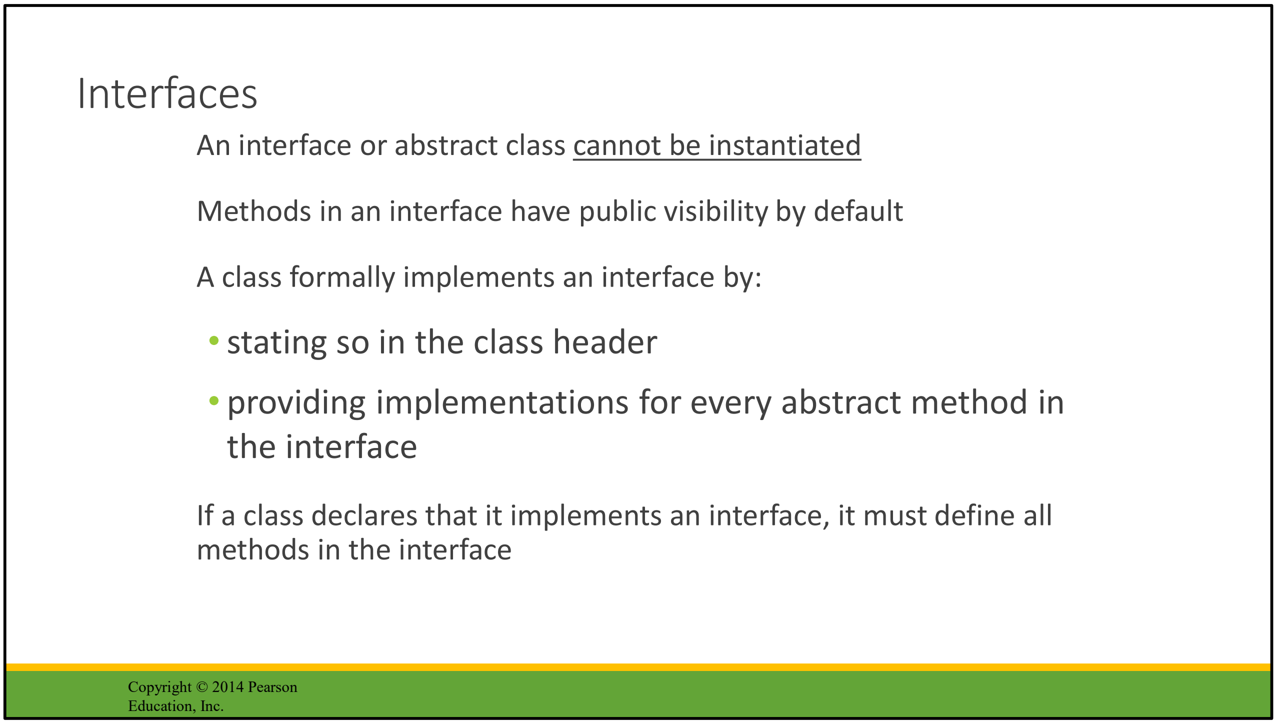
Interfaces

None of the methods in
an interface are given
a definition (body)

`interface` is a reserved word

```
public interface Doable
{
   public void doThis();
   public int doThat();
   public void doThis2(double value, char ch);
   public boolean doTheOther(int num);
}
```

A semicolon immediately
follows each method header



Interfaces

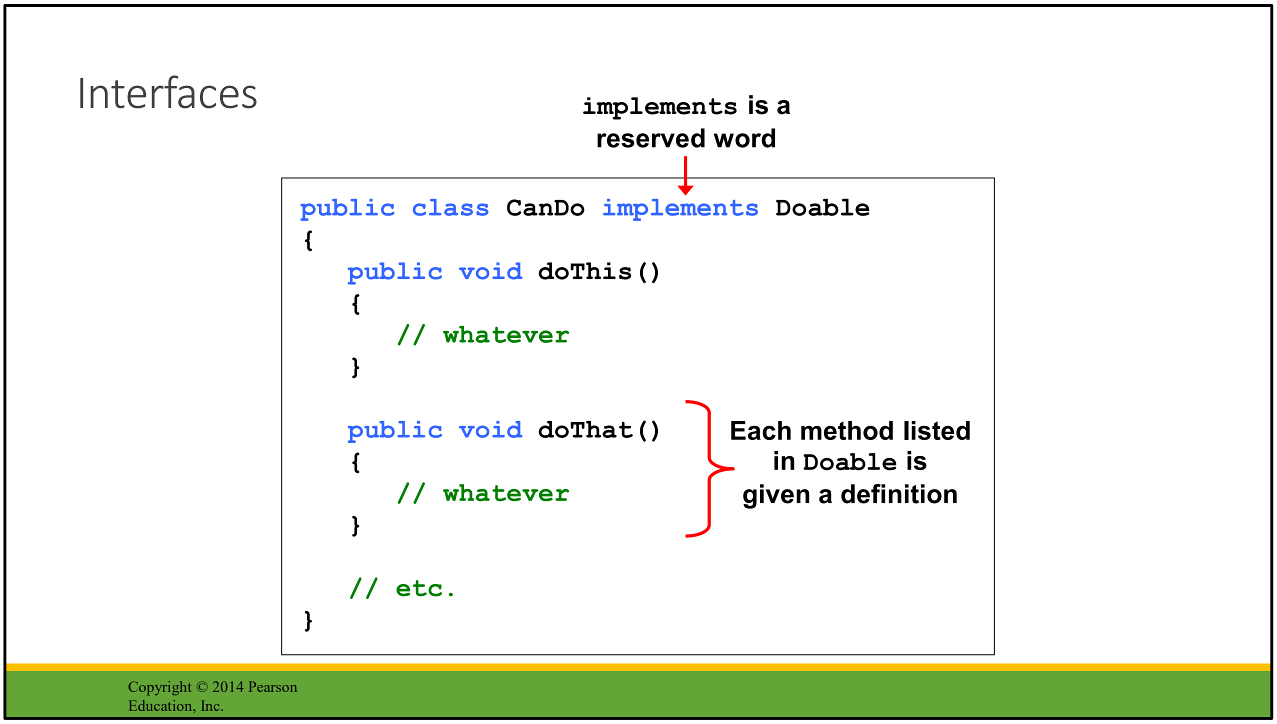
An interface or abstract class cannot be instantiated

Methods in an interface have public visibility by default

A class formally implements an interface by:

- stating so in the class header
- providing implementations for every abstract method in the interface

If a class declares that it implements an interface, it must define all methods in the interface



Interfaces

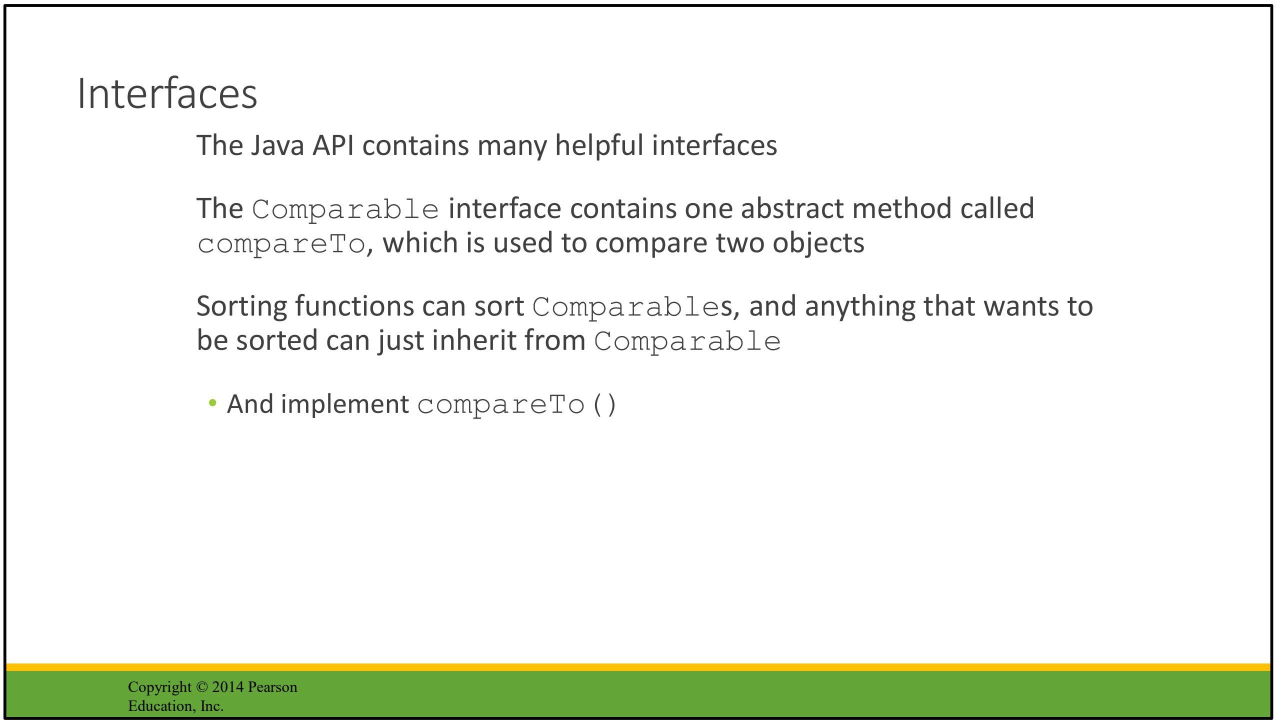
implements is a reserved word

```
public class CanDo implements Doable
{
   public void doThis()
   {
      // whatever
   }

   public void doThat()
   {
      // whatever
   }

   // etc.
}
```

Each method listed in Doable is given a definition



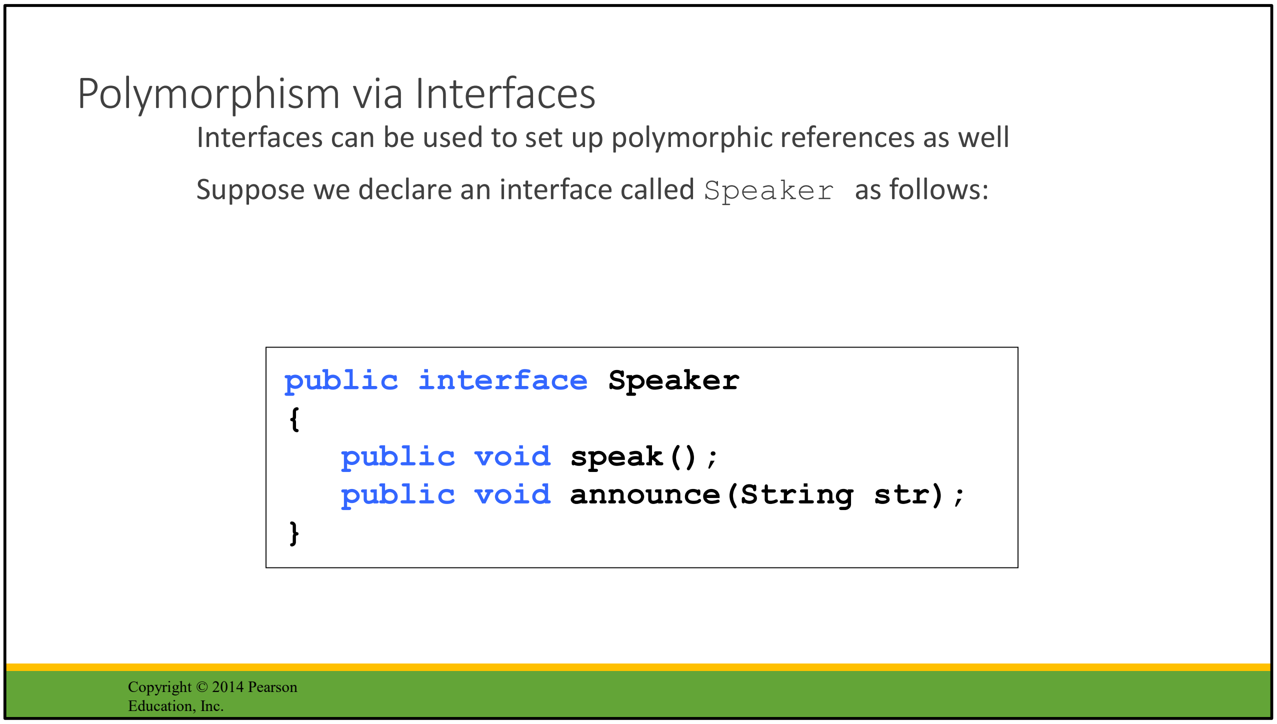
Interfaces

The Java API contains many helpful interfaces

The `Comparable` interface contains one abstract method called `compareTo`, which is used to compare two objects

Sorting functions can sort `Comparable`s, and anything that wants to be sorted can just inherit from `Comparable`

- And implement `compareTo()`

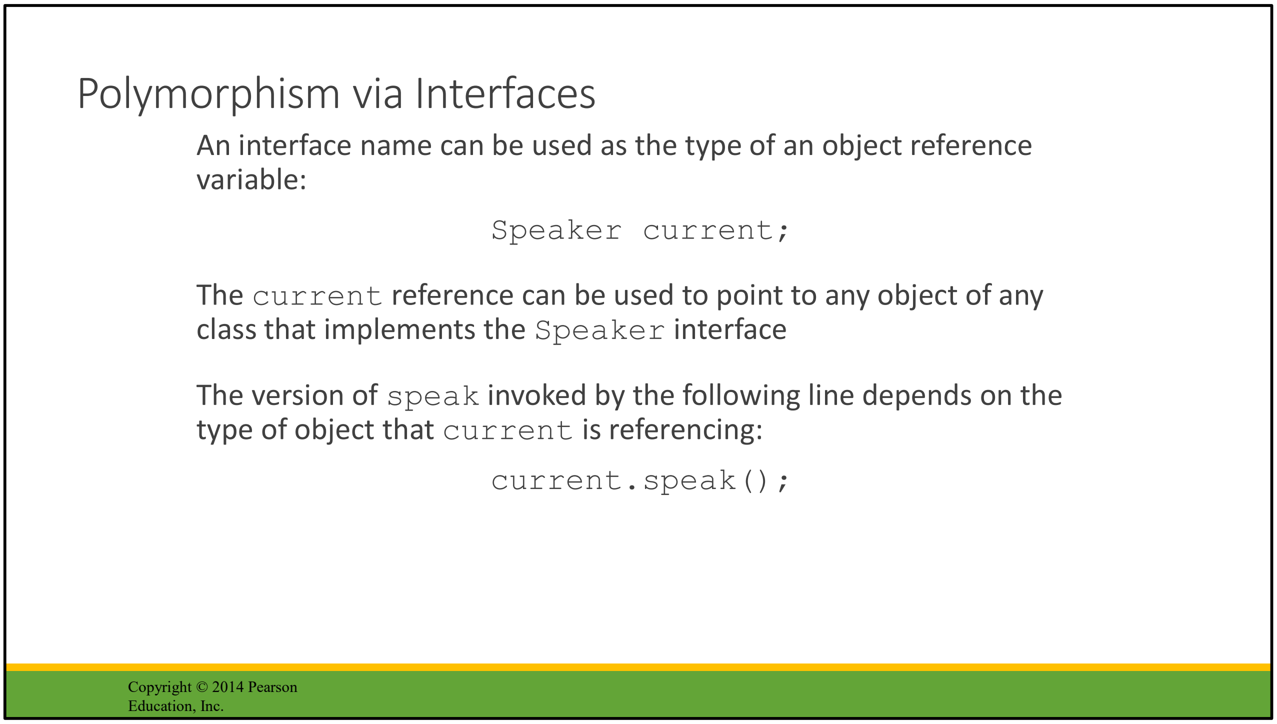


Polymorphism via Interfaces

Interfaces can be used to set up polymorphic references as well

Suppose we declare an interface called `Speaker` as follows:

```
public interface Speaker
{
   public void speak();
   public void announce(String str);
}
```



Polymorphism via Interfaces

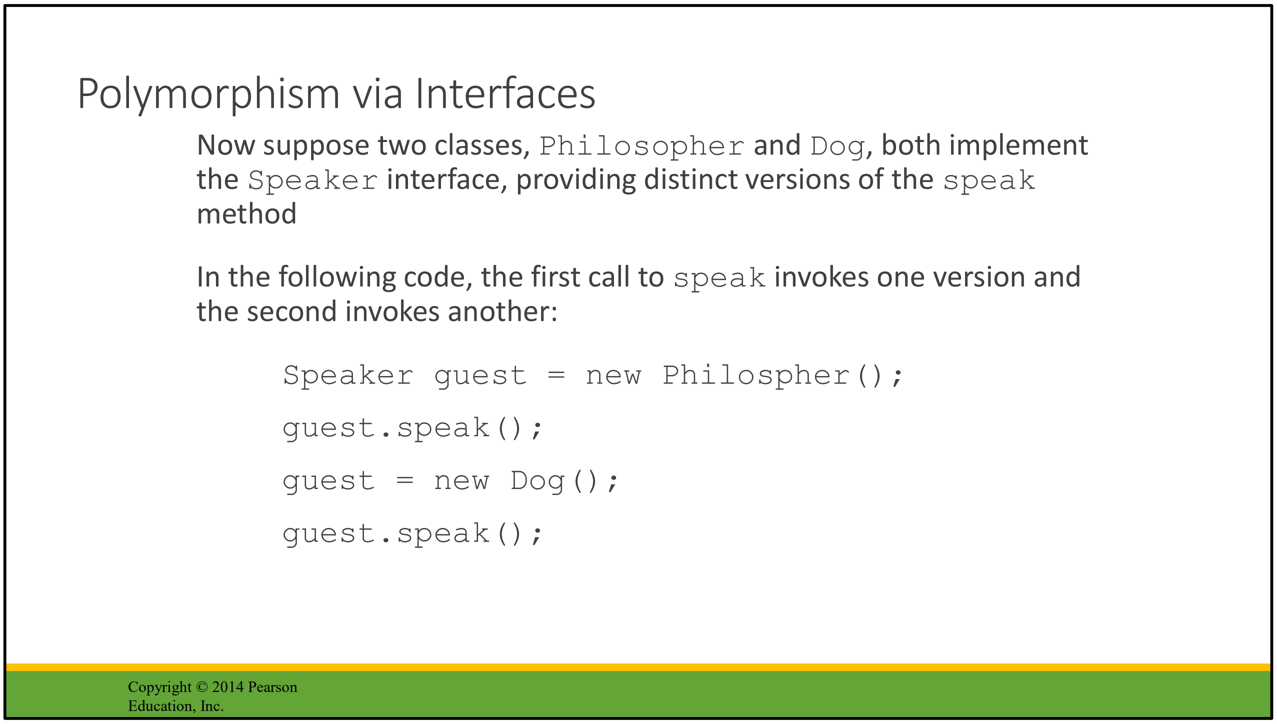
An interface name can be used as the type of an object reference variable:

```
Speaker current;
```

The `current` reference can be used to point to any object of any class that implements the `Speaker` interface

The version of `speak` invoked by the following line depends on the type of object that `current` is referencing:

```
current.speak();
```

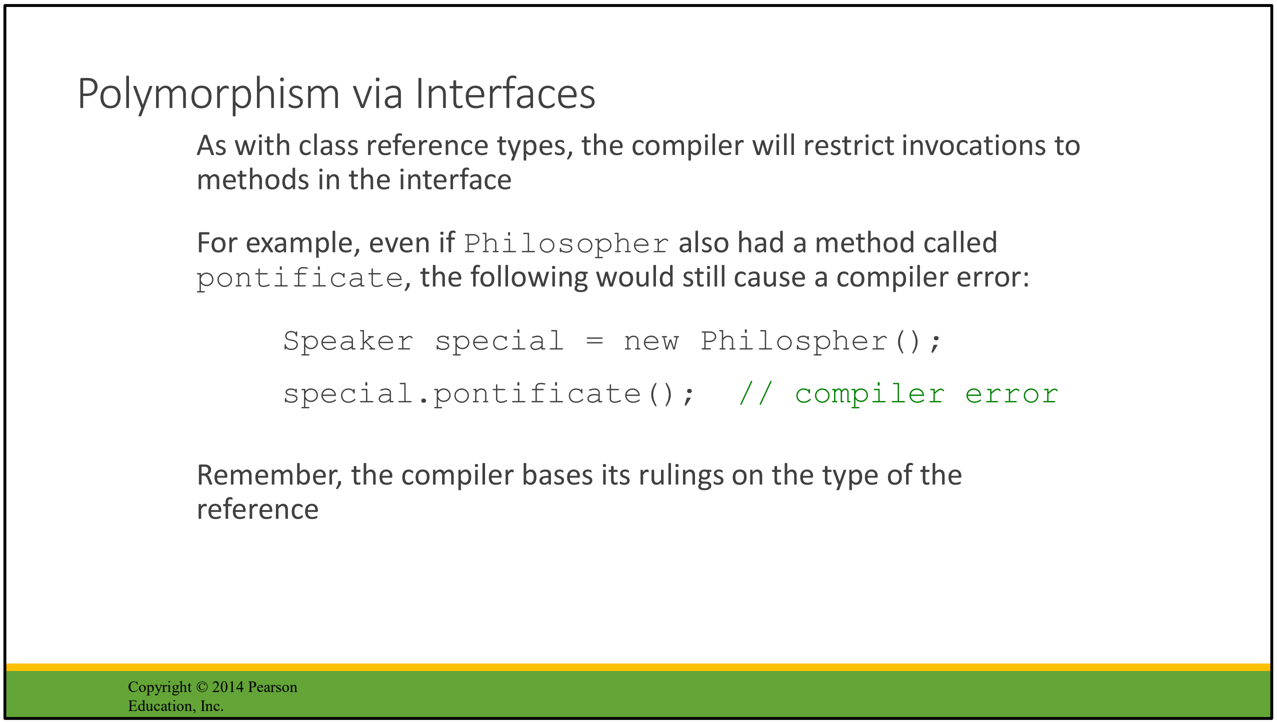


Polymorphism via Interfaces

Now suppose two classes, `Philosopher` and `Dog`, both implement the `Speaker` interface, providing distinct versions of the `speak` method

In the following code, the first call to `speak` invokes one version and the second invokes another:

```
Speaker guest = new Philospher();
guest.speak();
guest = new Dog();
guest.speak();
```



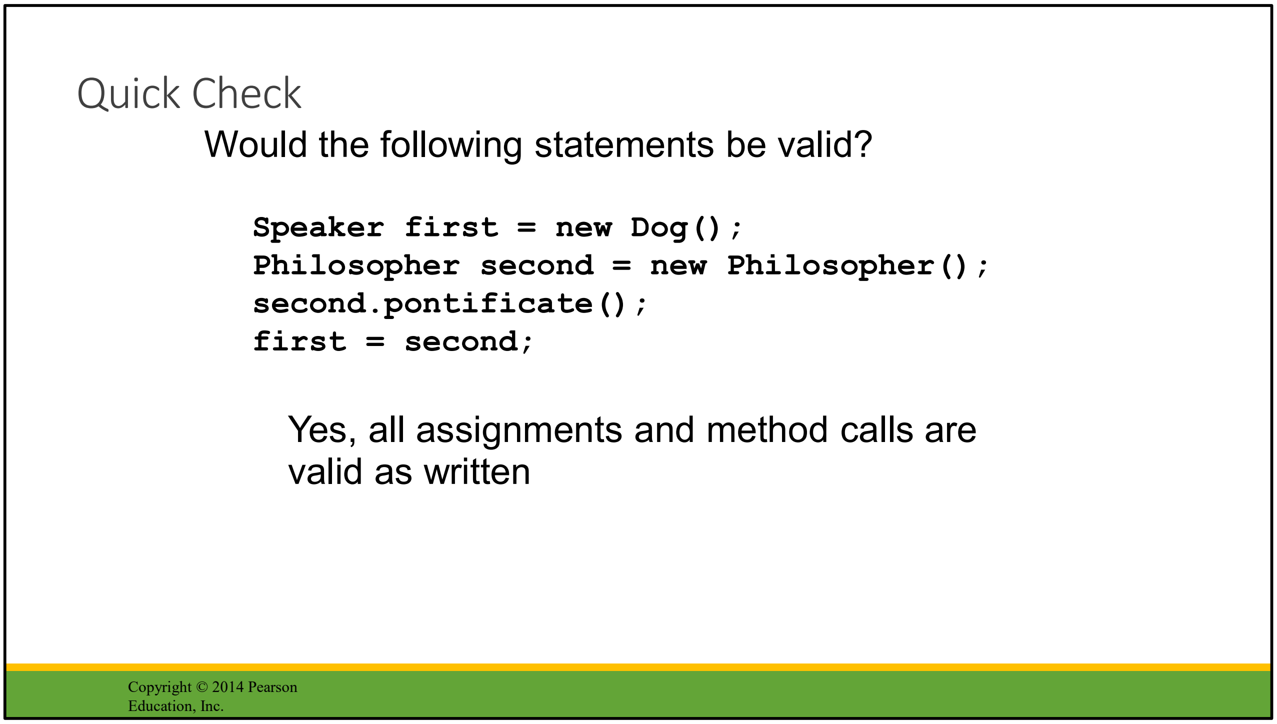
Polymorphism via Interfaces

As with class reference types, the compiler will restrict invocations to methods in the interface

For example, even if `Philosopher` also had a method called `pontificate`, the following would still cause a compiler error:

```
Speaker special = new Philospher();
special.pontificate();  // compiler error
```

Remember, the compiler bases its rulings on the type of the reference

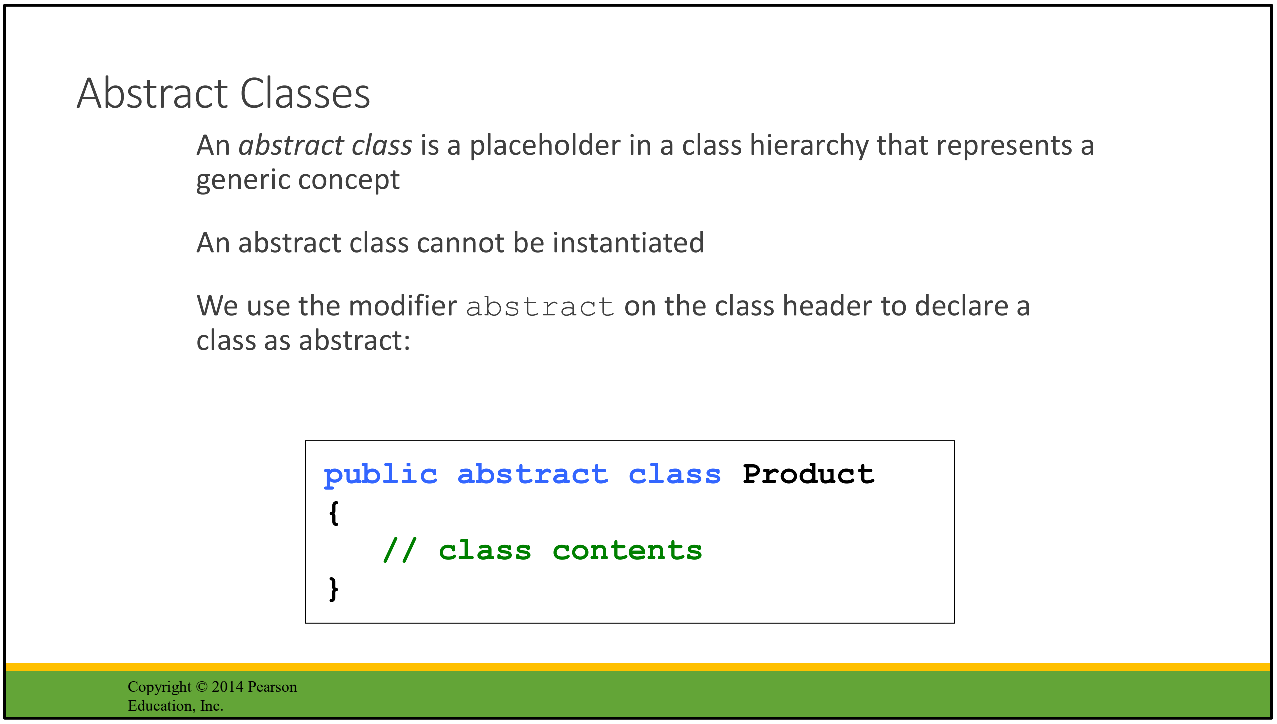


Quick Check

Would the following statements be valid?

```
Speaker first = new Dog();
Philosopher second = new Philosopher();
second.pontificate();
first = second;
```

Yes, all assignments and method calls are valid as written



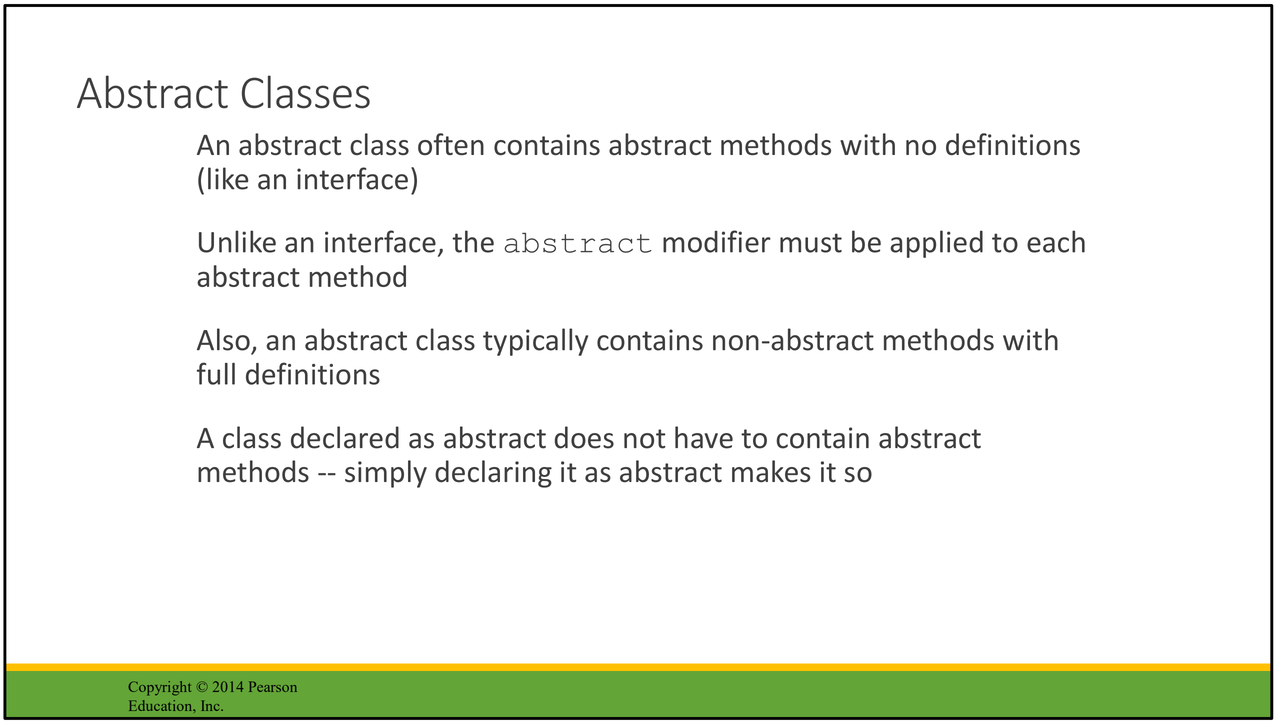
Abstract Classes

An *abstract class* is a placeholder in a class hierarchy that represents a generic concept

An abstract class cannot be instantiated

We use the modifier `abstract` on the class header to declare a class as abstract:

```
public abstract class Product
{
   // class contents
}
```



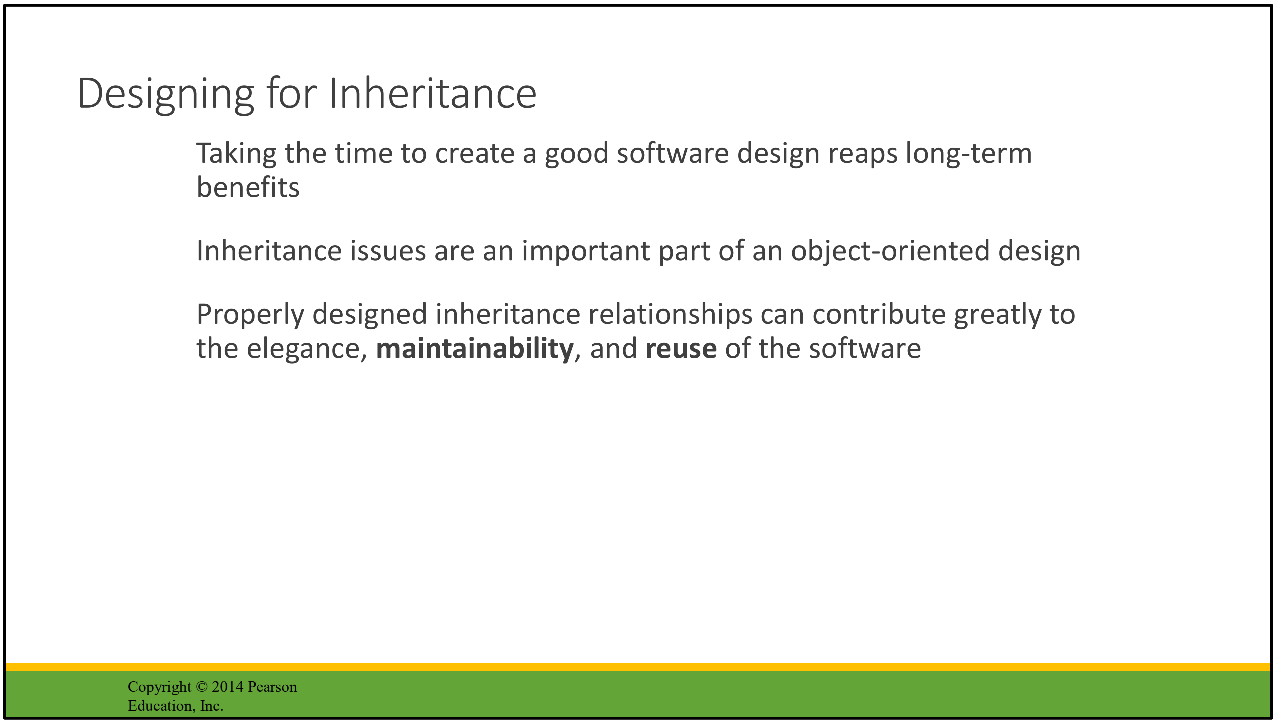
Abstract Classes

An abstract class often contains abstract methods with no definitions (like an interface)

Unlike an interface, the `abstract` modifier must be applied to each abstract method

Also, an abstract class typically contains non-abstract methods with full definitions

A class declared as abstract does not have to contain abstract methods -- simply declaring it as abstract makes it so

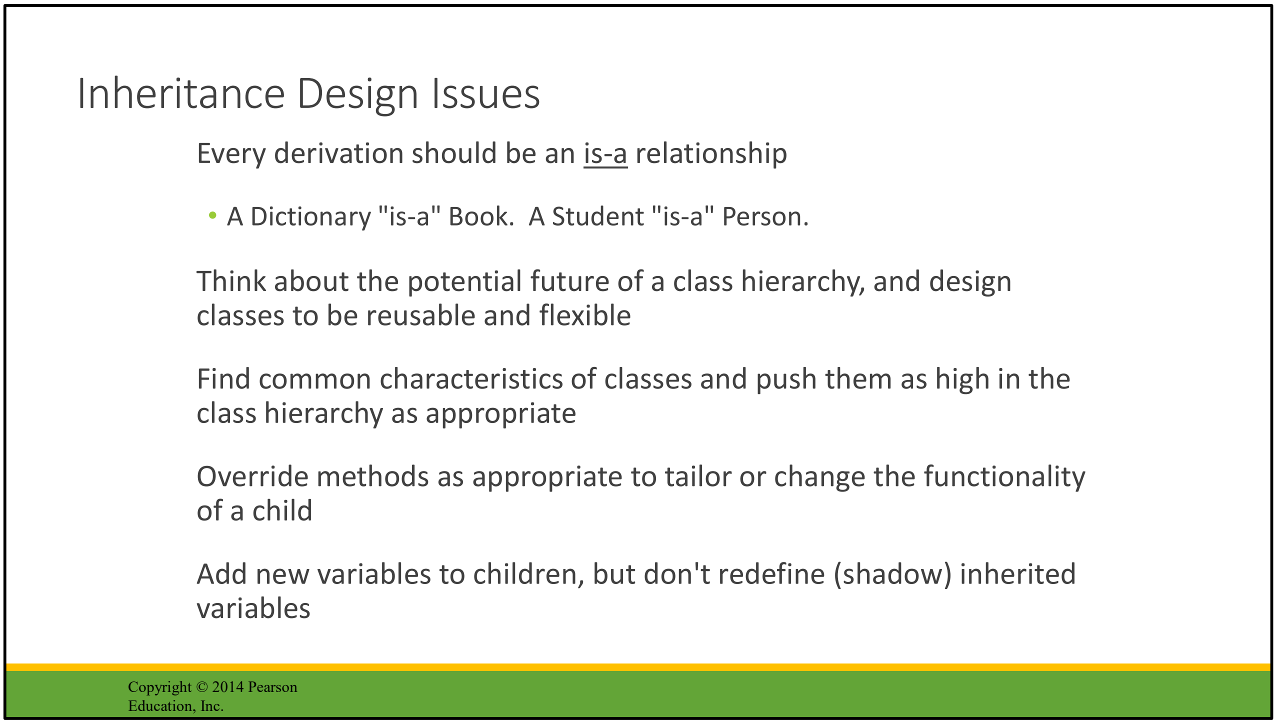


Designing for Inheritance

Taking the time to create a good software design reaps long-term benefits

Inheritance issues are an important part of an object-oriented design

Properly designed inheritance relationships can contribute greatly to the elegance, **maintainability**, and **reuse** of the software



Inheritance Design Issues

Every derivation should be an is-a relationship

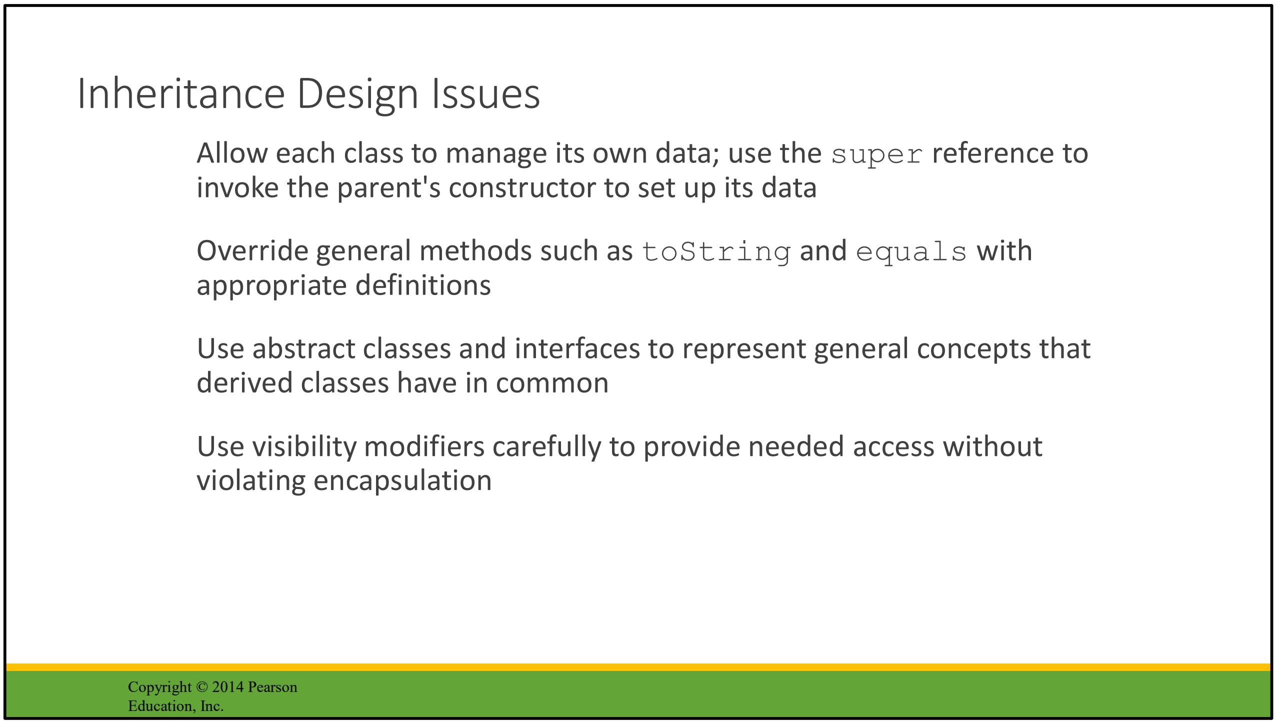
- A Dictionary "is-a" Book. A Student "is-a" Person.

Think about the potential future of a class hierarchy, and design classes to be reusable and flexible

Find common characteristics of classes and push them as high in the class hierarchy as appropriate

Override methods as appropriate to tailor or change the functionality of a child

Add new variables to children, but don't redefine (shadow) inherited variables



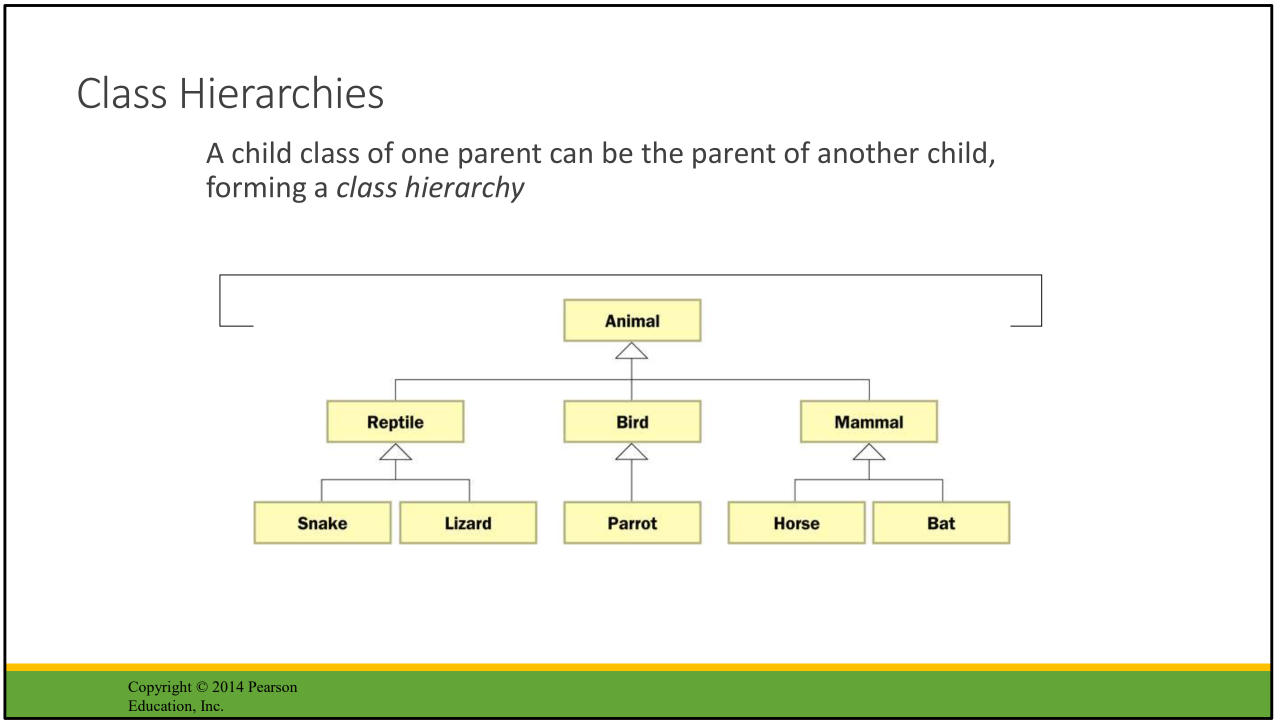
Inheritance Design Issues

Allow each class to manage its own data; use the `super` reference to invoke the parent's constructor to set up its data

Override general methods such as `toString` and `equals` with appropriate definitions

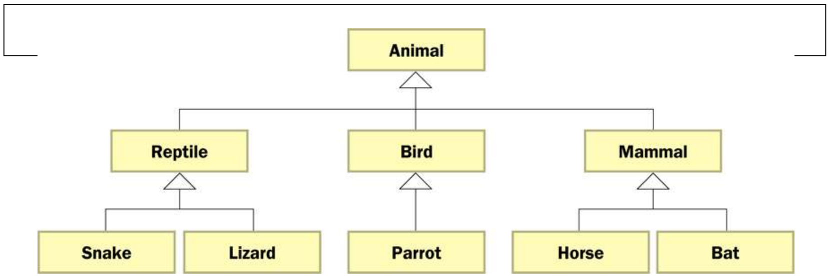
Use abstract classes and interfaces to represent general concepts that derived classes have in common

Use visibility modifiers carefully to provide needed access without violating encapsulation



Class Hierarchies

A child class of one parent can be the parent of another child, forming a *class hierarchy*



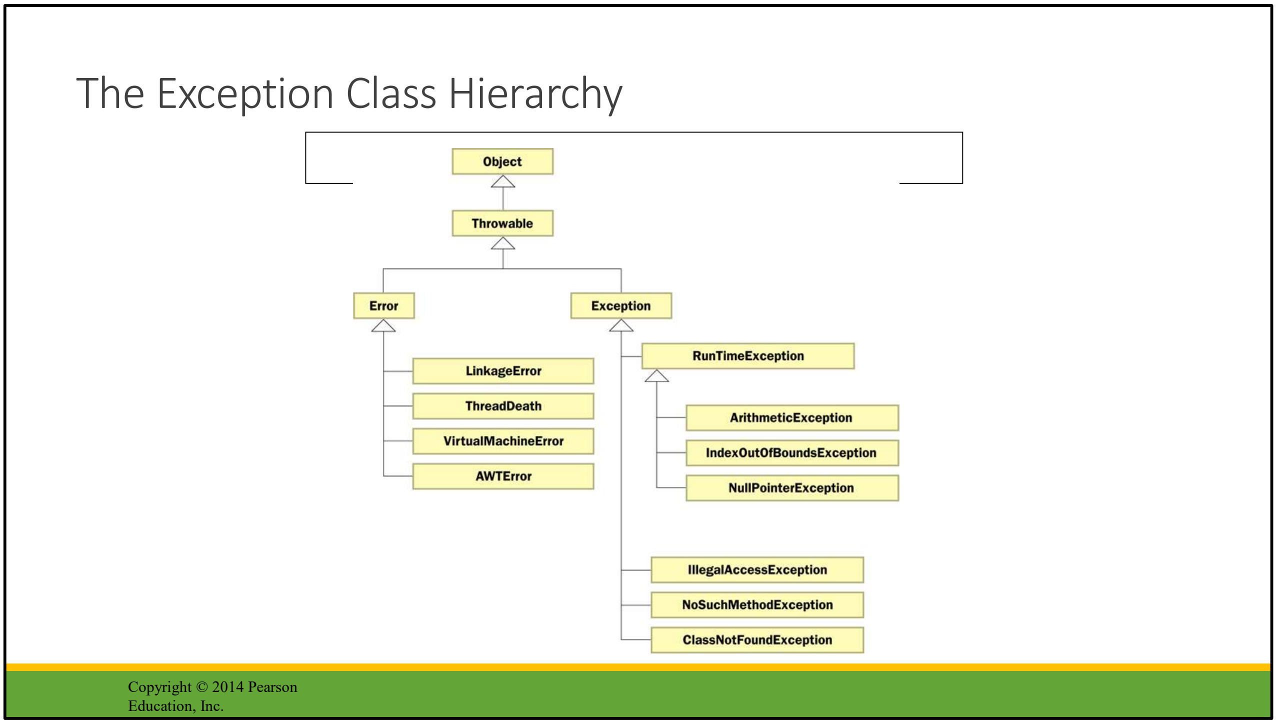
The Exception Class Hierarchy

Exception classes in the Java API are related by inheritance, forming an exception class hierarchy

All error and exception classes are descendents of the `Throwable` class

A programmer can define an exception by extending the `Exception` class or one of its descendants

The parent class used depends on how the new exception will be used



The Exception Class Hierarchy

Object

Throwable

Error

LinkageError

ThreadDeath

VirtualMachineError

AWTError

Exception

RunTimeException

ArithmeticException

IndexOutOfBoundsException

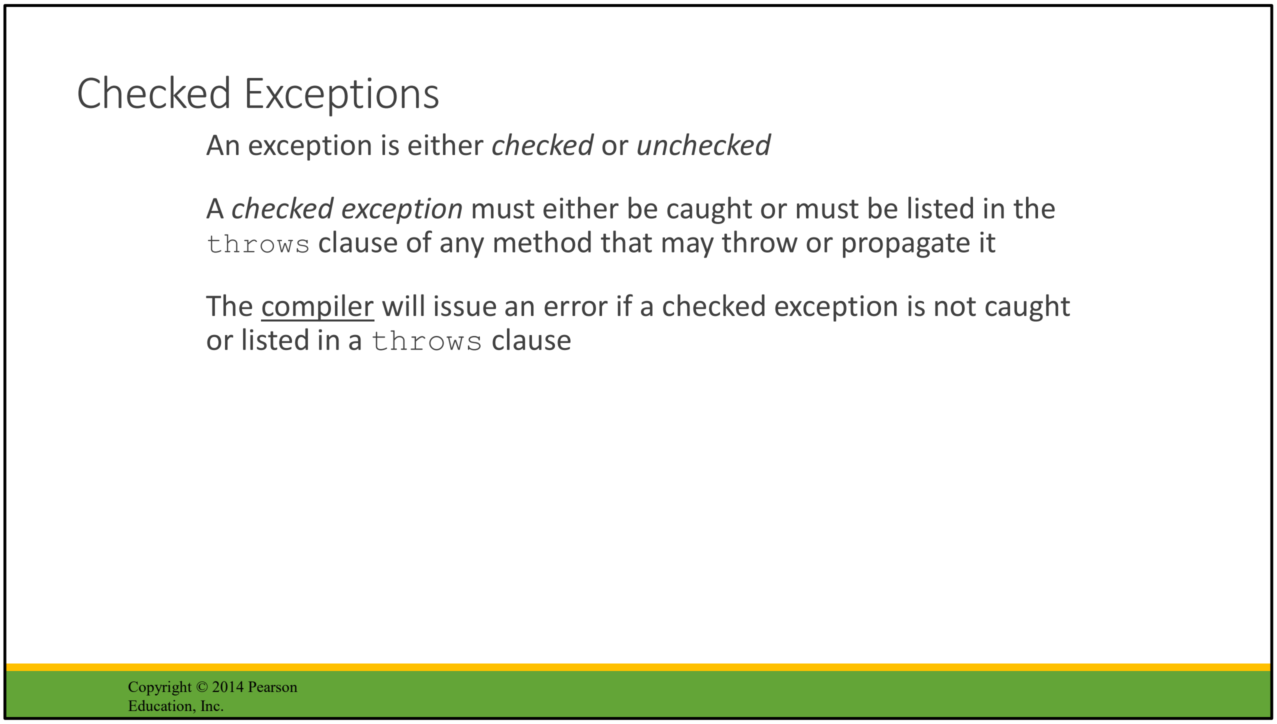
NullPointerException

IllegalAccessException

NoSuchMethodException

ClassNotFoundException

ERRORS SHOULD NOT BE HANDLED. Philosophy is to let the program fail. If you were flying the space shuttle, you'd be a little nervous if the life support system were running Java, no?



Checked Exceptions

An exception is either *checked* or *unchecked*

A *checked exception* must either be caught or must be listed in the `throws` clause of any method that may throw or propagate it

The compiler will issue an error if a checked exception is not caught or listed in a `throws` clause

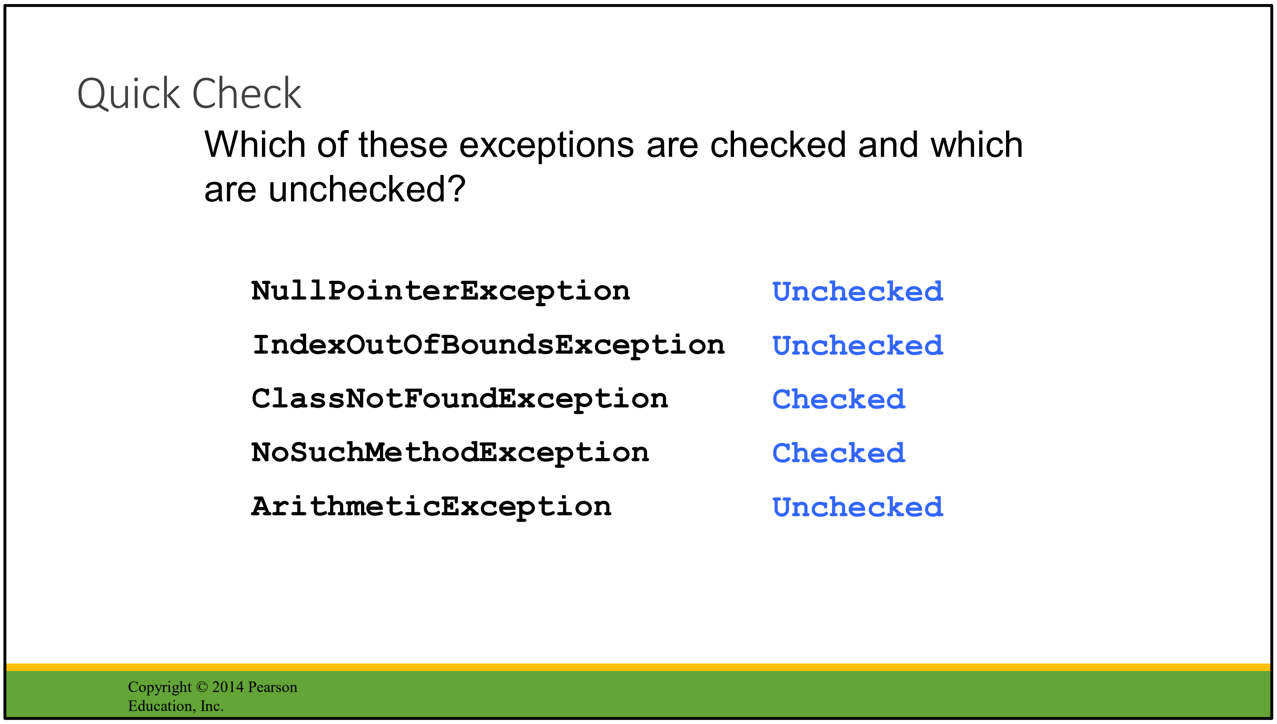
Unchecked Exceptions

An unchecked exception does not require explicit handling, though it could be processed that way

The only unchecked exceptions in Java are objects of type `RuntimeException` or any of its descendants

Errors are similar to `RuntimeException` and its descendants in that:

- Errors should not be caught
- Errors do not require a `throws` clause



Quick Check

Which of these exceptions are checked and which are unchecked?

`NullPointerException`	Unchecked
`IndexOutOfBoundsException`	Unchecked
`ClassNotFoundException`	Checked
`NoSuchMethodException`	Checked
`ArithmeticException`	Unchecked